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(54) Title: MINERAL WOOL PLANT SUBSTRATE

(57) Abstract

The invention relates to a mineral wool plant substrate comprising a coherent matrix of mineral wool and up to 20 volume % of an ion–exchange agent comprising a variable and/or fixed ion–exchange capacity of about 15, preferably 30 and most preferably 40meq/100g dry weight or more.

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MINERAL WOOL PLANT SUBSTRATE

The present invention relates to a mineral wool plant substrate, more in particular to a mineral wool plant substrate comprising a foreign material or materials in order to improve the properties of the mineral wool substrate to realize Crop Protection and/or improve plant performance in relation to additions (such as nutrients, pesticides, water and the like) as applied by growers during a cropping cycle.

Mineral wool plant substrates for plant growth are well-known in the art and consist of a coherent matrix of mineral wool. This coherent matrix is formed by collecting a layer of mineral wool fibres provided with a curable binder, so that after curing the mineral wool fibres are substantially not displaceable relative to one another. If required for fast uptake of water this coherent matrix of mineral wool may be provided with a wetting agent.

Under mineral wool is to be understood glass wool, stone wool, rock wool, man made vitrous fibres, slag wool, and/or mixtures thereof.

The fibres may have an average diameter varying in between 1-10 μm. For rock wool the fibre diameter is on average about 4 μm.

The density of the coherent matrix of mineral wool may be between 10-200 kg/m^3, in general in the range of 40-80 kg/m^3.

Such a coherent matrix of mineral wool has a form retaining property, which is inherent due to the inorganic starting materials used. Furthermore, the water retaining capacity of these mineral wool plant substrates is very well controllable and predictable.

A problem is that growers, utilizing such mineral wool plant substrates may inadvertently stress and even damage plants by overdosing or underdosing the mineral wool substrates with additions, such as nutrient

solutions, when considering plant requirements at a certain time and growth stage.

An object of the present invention is to provide an improved mineral wool plant substrate, which aims to overcome this problem.

According to a first aspect of the present invention there is provided a mineral wool plant substrate according to claim 1.

In soil, plants extract their necessary compounds such as essential nutrients from available compounds in the soil water. If the amount of compounds in the soil water either exceeds or is less than the amount required by the plant, these compounds will be respectively released or stored on charged soil particles. This can be quantified as the ion exchange capacity (IEC). These soil particles may contain both a fixed and/or a variable IEC (variable meaning that the amount of IEC is dependent on other parameters such as pH, water content and structure).

The mechanism of release and storage is based on the chemical equilibria of compounds between soil particles and the soil water solution and/or soil particles and soil air solution.

This IEC and the mechanism for release and storage of compounds in soils not only works for ions, but is also appropriate for compounds which are electrically neutral, but due to their chemical structure contain strong positive and negative dipole charges, examples being water and organic compounds such as carbon-acids and alcohols.

This mechanism for exchanging and storage of compounds and IEC is however lacking in mineral wool plant substrates. Therefore, if growers over or underdose mineral wool substrates with for example nutrients and pesticides, this can have a severe negative effect on the plants (such as stress, damage and the like) resulting in a suboptimal growth response, both qualitatively and

quantitatively. The plant stress induced in this way, can even result in the induction of plant diseases.

The inventors have shown that by adding an ion exchange agent containing a fixed and/or variable IEC to mineral wool plant substrates, vital compounds are buffered therewithin. This means that if a grower adds an over or under dose of compounds to the plant substrate the plant is substantially prevented from negative effects thereby.

The ion-exchange agent is preferably a cation exchange-agent which comprises soil minerals, and most preferably exhibits a non-clay like behaviour with respect to swelling and shrinkage.

Micro-organisms can be very important to the growth of the plant. On the one hand such organisms play a role in plant protection, for example the occurrence plant diseases induced by pathogens and/or predators (such as phythium and Protozoa) are prohibited by both optimized crop conditions (such as sufficient nutrients) and the appearance of antagonists, i.e. micro-organisms, of these pathogens and predators, and on the other hand, micro-organisms (such as mycorizha) can live in symbioses with the plant and in this way induce improved plant growth.

A good habitat for micro-organisms is available in materials containing pores with an average size of 6 μm or less. Very good conditions are provided when the pores are smaller than 3 times the size of the micro-organisms, yet still larger than the organisms. Clay (such as Bentonite) is an example of a material containing an average pore size < 6 μm. The porosity and average pore size of clay is not static but fluctuates considerably due to the swell and shrink behaviour of clay, which is influenced, amongst other things by the pH-level, EC-level and water content.

Plant pathogens and predators are bigger in size than known antagonist and plant beneficial micro-

organisms. The latter are therefore more likely to profit from this smaller pore size.

In mineral wool plant substrates having a density of 10-200 kg/m^3 the average pore size is most likely to be larger than 10 μm. Mineral wool plant substrates have a stable structure and porosity and are substantially not sensitive to swell and shrink behaviour.

In order to improve the mineral wool plant substrate as a microbiological habitat, especially for plant protective micro-organisms, the ion-exchange agent preferably has an average pore size smaller than a mineral wool substrate of about 72 kg/m^3 (which has approximately an average pore size of 25 μm), preferably also exhibits less swelling and shrinkage than clay and most preferably has an average pore size < 6 μm.

Most preferably the ion-exchange agent comprises a zeolite. Since zeolites have a stable, cage like structure they offer an ideal, stable habitat for micro-organisms.

The substrate may further more comprise an organic substance like peat, coco, sphagnum or several types of compost, preferably to a degree of humification of 10-70%, more preferably comprising 10-60% humic acids and/or nitrogen compounds (such as proteins, amino acids and amides) and most preferably originating from a natural source, which can substitute the mineral wool for upto 20 volume %, preferably upto 10 volume %.

Suitable organic substances are referred to in WO 96/33602 which are included herein by reference.

PH control in cropping is often required for a good growth response. However, with mineral wool plant substrates good pH control is difficult to achieve. The pH resulting from the nutrient solution (based on the required pH plant growth) often differs from the actual found pH in the mineral wool substrate. This is due to several reasons.

Firstly the mineral wool plant substrate behaves basic chemically, and therefore the pH in the substrate increases.

Secondly plants extrudate organic substances from their surroundings which can influence pH.

Uptake of nutritional ions leads to the exclusion of H^+ and OH^- by plant roots which can also influence the pH. Furthermore the state of the plant conditions, i.e. considering factors such as induced stress can also influence the type and amount of nutrient uptake and exclusion of extrudates.

Organic substances are good at buffering H^+ ions via ad- and de-sorption of NH_2 groups and buffering of OH^- ions via carbon-acid like groups (such as fulvic and Humic acids).

Organic matter is also susceptible to biological degradation, affecting structure, amount and function of the effective pH buffering groups and therefore the pH buffering capacity of the organic matter. The degree of humification of organic substances is an indication for the possible degree and amount of degradation. Substances with a low degree of humification are more likely to degrade than substances with a high degree humification. However, by using biologically degradable organic substances the mineral wool plant substrate provides further advantageous properties linked to the organic substance, being the provision of a carbon source. Further, due to the degradation of the organic substance plant stimulating compounds are released such as humic acids and vitamins which are beneficial to plant growth. Chelate forming compounds which keep slight or insoluble trace elements in the nutrient solution may also be released. The organic substance preferably has a degree of humification varying between 10-70% in order to provide good pH buffering and positive effects on degradation.

When it is desired to provide a mineral wool plant substrate with an improved water buffering capacity

with higher available amounts of water between pF 0.5 and 2 and/or a more intermediate and fixed IEC, it is worthwhile to partially substitute the mineral wool by an inorganic substance such as a natural clay. The clay may substitute the mineral wool for up to 20 volume %.

Clay for substitution of the organic substance may comprise soil materials comprising hydrophilic particles preferably having a particle size below 20 μm, such particles, for example, belonging to the class of eroded minerals, such as clays, mixtures of clays with silt and sand having a clay fraction removable as sludge of at least 20%, and further bentonite, kaolin and the like. Particularly suitable are different naturally occurring types of clays or mixtures thereof, such as young sea clay. Examples are clays comprising 0-100%, preferably 10-50% of particles having a size preferably being smaller than 20 μm.

The use of clay provides another advantage when the organic substance is included in the matrix in the form of a pellet. In this situation clay functions as a lubricating agent and as a material that reduces the compressibility of the pellet.

The combination of clay and organic matter forms a so called clay-humus complex which can lead to an improved physical structure i.e. increased porosity, increased pore sizes and therefore a drier, more aerated structure.

Accordingly, the amount of clay may be used in order to change the biodegradable character of the organic substance used. For example peat which is normally biodegradable may rendered substantially bio-undegradable due to the addition of clay to the pellet.

In this manner, clay may inhibit or retard the biodegradation of the inorganic substance.

The pellet may have a (particle) size of about 0.1-20 mm.

Due to the presence of clay and of peat the concentration of spore elements in the water residing within the mineral wool matrix may be controlled, due to

the sustained release of cations temporarily stored within the organic substance and/or clay.

The invention will now be further elucidated by reference to the following examples.

Example 1

A coherent growth substrate was prepared having the form of grow-blocks (10*10*6.5 cm) consisting of a coherent matrix of mineral wool to which a phenol-formaldehyde based binding agent and a wetting agent was applied. Prior to passage through a curing oven, zeolite in a quantity of 10 weight % (particle size 2-6 mm having a cation exchange Capacity of 80 meq/100 gram dry matter) was added to the matrix. The density of the coherent growth substrate amounted to 80 kg/m^3. The CEC of the coherent growth substrate based on volume contained a CEC of 3-6 mmol/litre substrate. This buffer capacity was 12-25% of the optimal applied nutrient solution.

Example 2

A coherent growth substrate was prepared having the form of grow-blocks (10*10*6.5 cm) consisting of a coherent matrix of mineral wool to which a furan based binding agent was applied.

(Binding agents as described in WO 97/07664 are included herewith by reference)

Prior to passage through a curing oven, an equal mixture of 50% zeolite and 50% clay, which together formed a quantity of 10 weight % was added to the matrix. The density of the coherent growth substrate amounted to 80 kg/m^3.

The CEC of the Zeolite was 80 meq/100 gram dry matter, particle size was 2-6 mm, and the average pore size was < 10 μm.

The CEC of the Clay was 20 meq/100 gram dry matter, particle size was 2-6 mm and the average pore size was 5-12 μm.

The average pore size of mineral wool matrix lay between 15-30 μm.

The CEC of the coherent growth substrate based on volume of the substrate contributed to a total CEC of 2-4 mmol/liter substrate. This buffer capacity was 8-16% of the optimal applied nutrient solution.

Based on the volume of the coherent substrate, less than 1% of the total volume of the substrate contained an average pore size of less than 12 μm.

The inventors have shown that was sufficient to establish two different ecological niches for micro-organisms of differing sizes compared to products without the addition of the ion exchange agent exhibiting only one ecological niche.

The added amount of clay contributed in an extra absolute amount of water of 1-2 volume% in pF range 0.5-1.5. The relative extra amount of water available in this pF range, increased from 2% for pF 0.5 to 14% for pF 1.3. Research indicated that the extra available amount of 1.5% in clay induced an improved growth response for cucumbers of 3-4% in the first 30 days of growth when applying a water regime lying between pF 1 and 1.3.

Example 3

A coherent growth substrate was prepared having the form of grow-slabs (100*15*7.5 cm) which consisted of a coherent matrix of mineral wool to which a Phenol-Formaldehyde based binding agent and wetting agent were applied. Prior to passage through a curing oven, a mixture of 90% zeolite and 10% organic matter, together forming 12 weight % was added to the matrix. The density of the coherent growth substrate amounted to 57 kg/m^3.

The CEC of the Zeolite was 80 meq/100 gram dry matter, particle size was 2-6 mm and the average pore size was< 10 μm.

The organic matter comprised more than 10% humic acid.

The average pore size of mineral wool matrix lay between 20-35 μm.

The CEC of the coherent growth substrate based on volume of the substrate contributed to a total CEC of 2-4.5 mmol/litre substrate. This buffer capacity was 8-16% of the optimal applied nutrient solution.

Based on the volume of the coherent substrate, less than 0.5% of the total volume of the substrate contained an average pore size of less than 10 μm. Research indicated that this is sufficient to establish two different ecological niches for micro-organisms of differing sizes compared to products without the addition of the ion exchange agent exhibiting only one ecological niche.

Example 4

A coherent growth substrate was prepared having the form of growing blocks (10*10*6.5 cm) consisting of a coherent matrix to which a furan based binding agent was applied.

Prior to passage through a curing oven, Clinoptilolite, a natural Zeolite (commercially available from the American company 'Zeopro'), in a quantity of 5 weight %, (having a CEC (cation exchange capacity) of 85 meq/100 gram dry matter), was added to the matrix. The density of the coherent growth substrate amounted to 80 kg/m^3. The CEC of the coherent growth substrate based on volume contained a CEC of 4 mmol / litre substrate. This buffer capacity was 17-18% of the optimal applied nutrient solution.

The invention is not limited to the above description; the requested rights are rather determined by the following claims.

CLAIMS

1. Mineral wool plant substrate comprising a coherent matrix of mineral wool and upto 20 volume % of an ion-exchange agent comprising a variable and/or fixed ion-exchange capacity of about 15, preferably 30 and most preferably 40meq/100g dry weight or more.

2. Substrate according to claim 1 wherein the ion-exchange agent is a cation-exchange agent.

3. Substrate according to claims 1 or 2 wherein the ion-exchange agent comprises soil minerals.

4. Substrate according to claims 1, 2 or 3 wherein the ion-exchange agent has a non-clay like behaviour with respect to swelling and shrinkage, and preferably has a stable zeolite, cage-like structure.

5. Substrate according to any of the previous claims wherein the ion-exchange agent has an average pore size smaller than the average pore size of mineral wool having a density of less than about 72 kg/m^3.

6. Substrate according to any of the previous claims wherein the ion-exchange agent comprises a zeolite.

7. Substrate according to any of the previous claims further comprising an organic substance, preferably comprising sphagnum, peat, substituting the mineral wool for upto 20 volume %, preferably upto 10 volume %.

8. Substrate according to any of the previous claims further comprising clay, substituting the mineral wool for up to about 20 volume %.

9. Substrate according to any of the previous claims for use as a growing block.

10. Substrate according to any of the claims 1-8 for use as a growing mat.

11. Substrate comprising a coherent matrix of mineral wool, a pre-determined amount of clay and a pre-determined amount of an organic substance, preferably comprising sphagnum, peat, substituting the mineral wool for upto 20 volume %, preferably upto 10 volume %.

INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/EP 99/05759

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A01G31/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A01G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 93 00797 A (GRODANIA AS) 21 January 1993 (1993-01-21) the whole document	1-3,5,9, 10
Y		7
A		4,8,11

X	WO 97 16961 A (ROCKWOOL GRODAN BV ;GROOT JACOB FRANK DE (NL); KNOP ALBERT WILLEM) 15 May 1997 (1997-05-15) the whole document	11
Y		7
A		1,2,8

X	GB 2 189 478 A (MOFFETT F WESLEY JR) 28 October 1987 (1987-10-28) the whole document	1,2
A		3-11

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 December 1999	27/12/1999

Name and mailing address of the ISA	Authorized officer
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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Intern ial Application No
PCT/EP 99/05759

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category '	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	WO 91 08662 A (ROCKWOOL INT) 27 June 1991 (1991-06-27) the whole document	1,3,8-10
A		2,4,5,7, 11
A	EP 0 260 106 A (KYODO SHIRYO CO LTD) 16 March 1988 (1988-03-16) claims	6
A	WO 97 07664 A (ROCKWOOL INT ;GROOT JACOB FRANK DE (NL); HUSEMOEN THOR BREDE (DK)) 6 March 1997 (1997-03-06) cited in the application	

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

...ormation on patent family members

Intern...al Application No
PCT/EP 99/05759

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9300797 A	21-01-1993	AU 2311592 A	11-02-1993
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PATENT COOPERATION TREATY

15

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
E SD/VV22/38		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP99/05759	06/08/1999	14/08/1998
International Patent Classification (IPC) or national classification and IPC A01G31/00		
Applicant ROCKWOOL INTERNATIONAL A/S et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 1 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
03/03/2000	20. 11. 00
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Lucchesi-Palli, C Telephone No. +49 89 2399 2093

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP99/05759

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

1-9	as originally filed				
Claims, No.:					
2-11	as originally filed				
1	as received on	19/10/2000	with letter of	19/10/2000	

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   - ☐ the description, pages:
   - ☐ the claims, Nos.:
   - ☐ the drawings, sheets:

5. ☒ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)
   see separate sheet

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 1 - 10
	No:	Claims 11
Inventive step (IS)	Yes:	Claims 1 - 10
	No:	Claims
Industrial applicability (IA)	Yes:	Claims 1 - 11
	No:	Claims

2. Citations and explanations
   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

ad section I.

point 3:

In present claim 1 it is claimed that the ion-exchange agent has a stable structure. However in the originally filed claims 1 and 4 as well as in the description it is stated that the agent has a stable zeolithe, cage-like structure. Consequently not any agent with a stable structure has been originally disclosed, but a specific agent. Consequently the subject matter of claim 1 goes beyond the disclosure of the application as originally filed.

ad section V:

Novelty:

Claims 1 to 10:

Document D2, WO93 00797, the description, page 5, line 10 to page 7, line 35, claims 1 to 9, disclosing a plant substrate comprising a coherent matrix of mineral wool, an ion-exchange agent (clay being a cation exchange agent) comprising a ion-exchange capacity of about 15 to 100meq/100g dry weight.

D2 discloses the use of about 30% by weight of clay and not up to 20% as claimed in claim 1. Furthermore D2 does not discloses that the ion-exchange agent should exhibit a non-clay behaviour with respect to swelling and shrinkage. Thus claim 1 fulfil the requirement of article 33(2) PCT.

Claim 11:

Document 1, WO97/16961, the description, page 3, line 10 to page 4, line 29 claims 1 to 5 discloses a substrate comprising a coherent matrix of mineral wool, up to 25% by weight of clay and an organic substance, sphagum, pressed peat, substituting the mineral wool up to 10%.

All features of claim 11 are thus known from D1 and claim 11 does not meet the requirements of article 33(2) PCT.

Inventive step:

None of the documents cited in the International Search Report discloses the use of an ion-exchange agent which should exhibit a non- clay behaviour as claimed in present claim 1. The chosen agent improves apparently the capacity of buffering.

Claim 1 meets thus the requirements of article 33(3) PCT.

Dependent claims 2 to 10 relate to specific embodiments of the subject matter claimed in claim 1 and fulfil the requirements set in the PCT.

The industrial applicability of the claimed subject matter is evident in the field of plant production.

ad section VII:
The description is not in conformity with the claims as required by Rule 5.1(a)(iii) PCT.

Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the document D1 and D2 is not mentioned in the description, nor are these documents identified therein.

The inclusion by reference to other patent applications should be deleted.

ad section VIII:

The dependent claims 4 and 6 are not in conformity with claim 1 (article 6 PCT).

[redacted] CLAIMS

1. Mineral wool plant substrate comprising a coherent matrix of mineral wool and upto 20 volume % of an ion-exchange agent comprising a variable and/or fixed ion-exchange capacity of about 15, preferably 30 and most preferably 40meq/100g dry weight or more, characterized in that the ion-exchange agent has a stable structure, exhibiting a non-clay like behaviour with respect to swelling and shrinkage.